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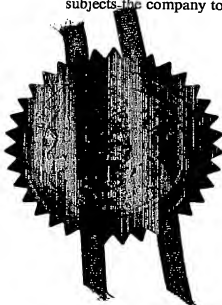
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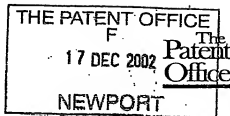
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P01/7700-0-00-0229290.2

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The Patent Office

Cardiff Road
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NP9 1RH

1. Your reference

P100690GB

2. Patent application number

(The Patent Office will fill in this part)

0229290.2

17 DEC 2002

3. Full name, address and postcode of the or of each applicant (underline all surnames)

QINETIQ LIMITED
Cody Technology Park
Farnborough
Ively Road, Farnborough
Hampshire GU14 0LX

Patents ADP number (if you know it)

If the applicant is a corporate body, give the country/state of its incorporation

8183873003
GB

4. Title of the invention

Radiation Focussing Element

5. Name of your agent (if you have one)

Harrison Goddard Foote

"Address for service" in the United Kingdom to which all correspondence should be sent (including the postcode)

Orlando House
11c Compstall Road
Marple Bridge
Stockport SK6 5HH
United Kingdom

Patents ADP number (if you know it)

14571002

6. If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and (if you know it) the or each application number

Country

Priority application number
(if you know it)

Date of filing
(day / month / year)

7. If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application

Number of earlier application

Date of filing
(day / month / year)

8. Is a statement of inventorship and of right to grant of a patent required in support of this request? (Answer 'Yes' if:

- a) any applicant named in part 3 is not an inventor; or
- b) there is an inventor who is not named as an applicant; or
- c) any named applicant is a corporate body.

See note (d)

Yes

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Continuation sheets of this form

Description 3
Claim(s) 3
Abstract 1
Drawing(s)

10. If you are also filing any of the following, state how many against each item.

Priority documents

Translations of priority documents

Statement of inventorship and right to grant of a patent (Patents Form 7/77) 1

Request for preliminary examination and search (Patents Form 9/77) 1

Request for substantive examination (Patents Form 10/77)

Any other documents (please specify) 1

Covering letter

11. I/We request the grant of a patent on the basis of this application.

Signature *Harrison Goddard Foote* Date 16.12.2002
Harrison Goddard Foote

12. Name and daytime telephone number of person to contact in the United Kingdom Roger Henderson 0161 427 7005

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DUPLICATE

Radiation Focussing Element

The present invention relates to a radiation focussing element.

International Patent Application No. WO/46768 (Secretary of State for Defence)
5 describes an imaging system which includes a diffraction grating which is distorted substantially according to a quadratic function to cause images to be formed under varying focus conditions. Our copending UK Patent Application No. 0205240.5 relates to a system for determining data relating to the local shape (or local phase distribution) of a radiation wavefront, and certain embodiments of that apparatus
10 comprise such a distorted diffraction grating.

Although particularly described in the context of optical radiation, these systems may be used with other forms of radiation.

Both of these patent applications show apparatus in which the distorted grating is located adjacent to a lens.

15 In a first aspect the present invention provides a radiation focussing element at least one surface of which is provided with at least one diffraction grating which is distorted substantially according to a quadratic function. Preferably the focussing element is or comprises a lens which is transmissive to the radiation (a dioptric element), for example a lens of glass, or a glassy material, although it could also be
20 (for example) of a polymeric material; alternatively the focussing element is or comprises a focussing reflector (a catoptric element).

In a preferred embodiment of the invention a single grating is disposed on only one surface of the focussing element. However, according to requirements, different gratings may be disposed on different areas of the same surface of the focussing
25 element, and/or (when the focussing element is a transmissive lens) a similar or different grating or gratings may be disposed on the opposed lens external surface.

In one embodiment the grating is a phase grating. It may be formed in the surface of the bulk (reflective or transmissive) element itself, for example by embossing or selective etching of the formed element, or by suitably moulding or otherwise shaping the element during manufacture.

- 5 Alternatively the grating may be formed in a layer covering at least part of the surface of the element, for example a layer made of a polymeric material or a glassy composition in which the grating is embossed or selectively etched.

Our copending UK Patent Application No. 0123744.5 describes and claims a method of providing an optical substrate with a surface having a desired shape, the method
10 comprising the steps of coating the surface with a thin layer of an optical glass, and subsequently modifying the shape of the external surface of the layer. As disclosed therein, the shaping of the glass layer may be imparted by etching or embossing. The glass layer may be of a chalcogenide glass, for example a glass consisting of Ge, As, Se and Te, which is rich in Te, or amorphous arsenic trisulphide. It may be deposited
15 by RF sputtering, flash evaporation, solvent evaporation or spin coating.

Furthermore, alternative processes may be utilised to form the grating, for example by coating of the surface of the focussing element with a photoresist, followed by exposure to interfering light beams, development of the resist pattern, and selective etching prior to removal of the remaining resist. In some cases, the developed resist
20 pattern may itself provide the grating without the need for etching.

Where the focussing element is a transparent lens a layer in which the grating is formed should be transmissive. Where the focussing element is reflective, the layer could again be transmissive; alternatively the grating could be formed in a reflective layer on a suitably shaped substrate so that the layer provides both the focussing and
25 grating functions.

In a development of the invention, e.g. where the size of the beam is important, an amplitude mask is located on at least one surface of the focussing element to provide an aperture. Thus in our copending UK Patent Application No. 0205240.5 mentioned above, the focussing and diffractive elements are located closely adjacent an aperture.

Such a mask could be provided in an additional layer of radiation (light) obscuring material on the said surface, either by selective deposition or selective removal, for example. Thus, whether the grating is a phase grating or an amplitude grating, it could be provided by a suitably shaped layer on the surface of the focussing element.

- 5 In another embodiment of the invention, the, each, or at least one of the phase gratings described above in relation to the invention is replaced by an amplitude grating. Again, this could be provided in an additional layer of radiation (light) obscuring material on a surface of the focussing element, either by selective deposition or selective removal, for example. Where the aperture mask is also
- 10 present, the grating and mask may be deposited sequentially or simultaneously, and they may be on the same surface or opposed surfaces of the focussing element.

The invention extends to a three-dimensional imaging system or a wavefront sensor comprising an optical element according to the first aspect of the invention.

- The systems described in the aforementioned International Patent Application No.
- 15 WO/46768 and UK Patent Application No. 0205240.5 are prone to chromatic aberration due to the dispersive properties of the grating, and this has been a limiting factor when attempting to apply the technology with broadband or white light. Accordingly in a preferred embodiment of lens focussing element, the dispersion inherent in the grating is reduced, and more preferably substantially compensated for,
- 20 by the lens itself, or one or more refractive element(s) thereof if it is a compound or composite lens. This enables the compound element to be used in a white light wavefront sensor or imaging system, for example in systems of the type described and claimed in our aforesaid patent applications.

- By forming the grating on the surface of the focussing element, a composite optical
- 25 element is formed which performs both the grating and focussing functions but which is not prone to misalignment problems between the focussing element and the grating due to shocks or other environmental factors. This advantage is compounded if an aperture is also required and it is also provided on the focussing element itself.

CLAIMS

1. A radiation focussing element at least one surface of which is provided with at least one diffraction grating that is distorted substantially according to a quadratic function.
- 5 2. A focussing element according to claim 1 wherein the focussing element comprises a radiation reflector providing said surface.
3. A focussing element according to claim 1 wherein the focussing element comprises a radiation transmissive lens providing said surface.
4. A focussing element according to claim 3 wherein only one surface of the lens
10 is provided with a said grating.
5. A focussing element according to claim 3 or claim 4 wherein the dispersion inherent in the grating is reduced by the lens itself, or by one or more refractive element(s) thereof.
6. A focussing element according to any preceding claim wherein the grating is a
15 phase grating.
7. A focussing element according to any one of claims 1 to 5 wherein the grating is an amplitude grating.
8. A focussing element according to any one of claims 1 to 7 wherein the grating is provided in a layer covering at least part of said surface.
- 20 9. A focussing element according to claim 8 wherein said layer is made of a glassy composition.
10. A focussing element according to claim 7 and claim 8 wherein said layer is made of a radiation obscuring material.
- 25 11. A focussing element according to any one of claims 8 to 10 wherein said layer is shaped.

12. A focussing element according to claim 2 wherein the reflector comprises a reflective layer on a substrate, and said reflective layer is shaped to provide said grating.
13. A focussing element according to any one of claims 1 to 6 wherein the grating is provided in the surface of the bulk element itself.
14. A focussing element according to any preceding claim and further comprising a mask on at least one surface of the element to provide an aperture.
15. A focussing element according to claim 14 wherein a said mask is provided in a layer on a surface of the focussing element.
16. A focussing element according to claim 14 or claim 15 wherein said mask and said grating are provided on the same surface of the focussing element.
17. A transmissive focussing element according to claim 14 or claim 15 wherein said mask and said grating are provided on the opposed surfaces of the focussing element.
18. A radiation focussing element according to any preceding claim for use with optical radiation.
19. A method of making an element according to any one of claims 11 to 13 wherein the grating is formed by embossing.
20. A method of making an optical element according to claim 11 or claim 12 wherein the grating is formed by selective etching.
21. A method of making an optical element according to claim 6 wherein the focussing element is a transmissive lens and the grating is formed by moulding during manufacture of the lens.
22. A three-dimensional imaging system comprising an element according to any one of claims 1 to 16.

23. A wavefront sensor comprising an optical element according to any one of claims 1 to 16.

Abstract

The or at least one surface of a reflective or transmissive radiation focussing element is provided with at least one phase or amplitude diffraction grating that is distorted substantially according to a quadratic function. The surface or the opposed surface
5 may also be provided with an aperture. The element is useful in three dimensional imaging and wavefront sensing systems.

(No figures)

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